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To: Mr. R. Coutts
Station Manager
Bruce NGS "A"

MAY 1987 BRUCE NGS A OUTAGE - FRP SPRAY HEADER INSPECTION

J.M. Braun

A detailed inspection of the vacuum building spray headers was carried out during the 1987 four unit Bruce NGS A outage after 10 years of service. Small material samples were cut from the headers for laboratory evaluation. All FRP components were found to be in excellent condition with high hardness and no evidence of cracks or significant deterioration. Tensile properties compared favourably with a recently manufactured pipe of similar size and winding angle. Minor deficiencies included resin flaking on two headers and water ingress into three field joints (out of all 32). All manhole covers were replaced during the outage.

As part of the 1987 four unit Bruce NGS A outage a detailed inspection of the vacuum building spray headers was carried out. The 16 spray headers are a component of the vacuum building dousing system. The system which consists also of an emergency water storage tank, risers and central downcomer is normally maintained under vacuum, and is triggered by a pressure rise in the main building, causing water from the emergency water storage tank to be pushed through the headers and their spray plates.

The spray headers were manufactured by Protective Plastics Ltd out of filament wound fiberglass reinforced plastic (FRP) pipe sections with associated flanges, manholes, manhole covers and hangers. Openings were cut into the body of the header for placement of the spray plates. Final assembly of the headers was made on site using two field joints. Vertical support is provided by three FRP hangers, with details as indicated on

job	file	date	report no.
32-050-130	835.5	October 15, 1987	87-212-K

Figure 1. Under normal operation the headers are partially filled with water to maintain a seal between the upper and lower vacuum chambers. As the vacuum building is not accessible under operation, the headers have not been inspected since station start up.

Past experience with the dousing system at Pickering NGS has indicated that fiberglasss reinforced plastic materials are very stable under normal vacuum building conditions /1/. Nonetheless concern over these materials has been expressed regarding their long term aging characteristics and aging programs are being currently carried out at the Research Division to quantify the time related changes in FRP. At the request of the AECB a detailed plan was submitted to assess the strength characteristics of the header materials: in addition to a complete visual inspection of 4 headers, destructive testing of one manhole cover and small header samples was proposed to measure changes in material modulus with time. To assist in the inspection of the headers a detailed stress analysis was carried out to determine the more highly stressed headers and the corresponding location on the header /2/.

The present report details the results of the inspection program and documents the repairs carried out.

1. Selection of Headers for Inspection

All 16 headers were examined from the circular catwalk as soon as access to the vacuum building was gained for selection of the four headers to be given a full inspection. Generally, all headers appeared to be in good condition. Some flaking on exterior surfaces was noted on headers 11 and 12 and these were selected for inspection. Otherwise there were no obvious deficiencies and two headers with the higher stresses shown by the stress analysis, headers 1 and 16, were also included for inspection.

2. Inspection of Headers

Inspection of the headers and associated hangers was performed in accordance with the inspection procedure tabled prior to the outage and included here as Appendix 1. Header inspection and cutting of sample material proceeded as scaffolding was being made available. Repairs to the sample holes were carried out in parallel with inspections and thickness measurements.

2.1 Visual Inspection

The visual inspection was aimed at the detection of cracks, delaminations or evidence of aging or water ingress (as per eg. ASTM 2563 and ASME N-155-2). Visual examination was carried out with the aid of lighting on both sides of the pipe: at the

Figure 1 Header Drawing

nominal pipe thickness (1.9 cm) the wall was sufficiently translucent to allow for a complete through the wall inspection. Visual inspection was augmented with thickness and hardness measurements taken with a Barcol impressor. Hardness is indicative of initial curing conditions and/or degradation on aging with values of 30 to 40 as indicative of a well cured sample. Thickness measurements were taken with a calibrated magnetic gauge for which access is necessary from both sides.

Detailed examination of the four headers, particularly near the identified high stress area (at 3 and 9 o'clock at the hanger close to the catwalk), revealed them to be in excellent condition after 10 years of service with consistently high hardness readings throughout. Hardness and thickness data are presented in Table 1 for the four headers at specific spray plate locations (see Figure 1 for header detail). Note in particular the high hardness readings recorded on the joints. Thickness in these locations could not be obtained with our instrument because of its maximum range of 32 mm. Note also that hardness measurements are a localised indicator and can drop substantially as a result of surface aspect without representing always inferior cure: in such cases (eg readings of 24) additional measurements were always taken in the vicinity to detect deterioration or lack of cure. No such instances were found. With the exceptions noted below the headers were largely free of defects and cracks and signs of time related deterioration. Most importantly none of the inner surfaces in contact with water (with the exception of the field joints) exhibited any signs of deterioration.

Minor deficiencies included: flaking of the outer resin coat on headers 11 and 12, water ingress into the inner reinforcement of one field joint each on headers 11 and 12 and a chip on header 5.

The flaking on headers 11 and 12, pictured in Figure 2, appeared more serious than found under close inspection. While it extended to both sections of the headers but not to the short embedded FRP section, flaking was limited to the outer surface. Furthermore the flaking was restricted to the last resin coat, the underlying corrosion liner had remained unaffected and uniformly hard without any sign of aging or degradation. It is believed that the flaking was the result of improper resin application. Given the excellent condition of the resin rich outer corrosion layer it was decided that repairs were not warranted.

The chip on header 5 (at 3 o'clock above the catwalk) is believed to have resulted during installation, particularly in view of its location . No evidence of cracks was found, however, in the vicinity; nonetheless minor repairs were done to cover the exposed glass (See section 3 for details).

Table 1

Bruce Vacuum Building Inspection

SAMPLE LOCATION		BARCOL HARDNESS OUTSIDE #1	#16	#11	#12	INSIDE #1	#16	#11	#12	THICKNESS (mm) #1	#16	#11	#12
0		33	41	n/a	n/a	35	38	30	35	20.6	20.2	19.0	n/a
3		38	41	36	39	36	31	38	36	18.8	19.2	20.0	18.1
6		38	37	39	39	40	38	40	38	18.0	17.6	19.6	18.1
9		32	40	40	38	39	33	38	38	17.3	18.1	18.7	19.3
12		32	40	41	41	33	33	34	36	17.8	18.4	19.2	18.8
15		35	41	38	35	34	31	41	36	17.7	17.5	19.7	19.0
18		32	40	38	40	34	35	34	37	17.1	18.5	19.4	18.6
21		33	38	39	32	38	34	38	38	17.7	18.8	20.6	19.0
23	*	31	42	39	37	30	29	34	38	>32	>32	>32	>32
24		37	38	33	35	39	20	38	38	19.2	19.0	25.9	17.2
27		37	39	36	38	39	39	31	40	17.2	19.0	18.5	16.8
30		32	42	n/a	n/a	35	38	30	n/a	17.0	17.8	19.1	n/a
33		38	32	32	35	38	35	39	37	17.6	19.8	18.1	17.7
36		39	37	38	38	40	36	31	42	17.6	19.0	17.6	17.5
39	*	40	40	38	38	37	37	40	36	>32	>32	>32	>32
42		35	31	38	45	40	28	38	38	17.3	18.3	17.8	16.5
45		n/a	34	42	n/a	n/a	35	40	41	n/a	20.6	19.4	17.4
47	*	n/a	41	30	n/a	n/a	30	34	n/a	n/a	>32	>32	>32

* Joints

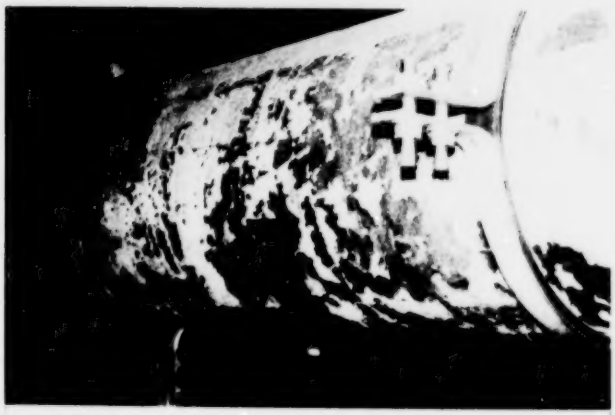


Figure 2

Detail of Resin Flaking and Sample Holes

Deficiencies in some field joints were observed, resulting in water ingress into the joint. As discussed each header was made up of one factory and two field joints: it was readily apparent, however, that the field joints lacked the professional finish, inside and outside, of the factory joints. The field joints showed some visible glass (between 9-12-3 o'clock, Figure 3) resulting from resin run off and pooling on the underside (around 6 o'clock). As listed in Table 1, however, both factory and field joints exhibited high hardness and were not cause for structural concern. It is felt that water ingress into the joint through the limited inner reinforcement layer was a result from incomplete filling of the gap with thixotropic resin. While the hand layup may have been done properly and left to cure to its fullest extent, water would nonetheless collect in the gap. It was also observed that the soft spots observed were all associated with unidentified black colored regions. The joints so affected were ground to sound glass, refilled and glass and resin applied as detailed in section 3.

Based on the observations on headers 1, 11, 12 and 16 it was decided to carry out a complete inspection of all field joints for evidence of water penetration: of all other field joints inspected one single joint in header #9 required repair. No other deficiency was observed in any of the headers in the course of this additional (internal) inspection.

2.2 Inspection of Associated Components

The associated components which formed an integral part of the inspection program included the spray plates, hangers, manhole flange and manhole cover. Note, however, that the covers were actually removed and replaced with new ones as also discussed more extensively in section 4.

All associated components were also found to be in excellent condition, exhibiting high Barcol hardness and without signs of deterioration or water ingress. The corresponding data are presented in Table 2 for hangers and in Table 3 for manhole flanges. Details of the FRP hangers are shown in Figure 3.

2.3 Post Douse Reinspection

A limited header inspection was carried out immediately following the vacuum building douse test. The inspection was carried out from the catwalk and consisted of a visual examination of all headers and associated components. In addition a thorough examination was carried out both inside and outside of Header #1 around the high stress area; the internal inspection was done up to and including the first field joint. All areas inspected were found to be completely unaffected by the douse test with no signs of resin or fiber cracking, including the repair patches and the new mancovers which were stressed for the first time.

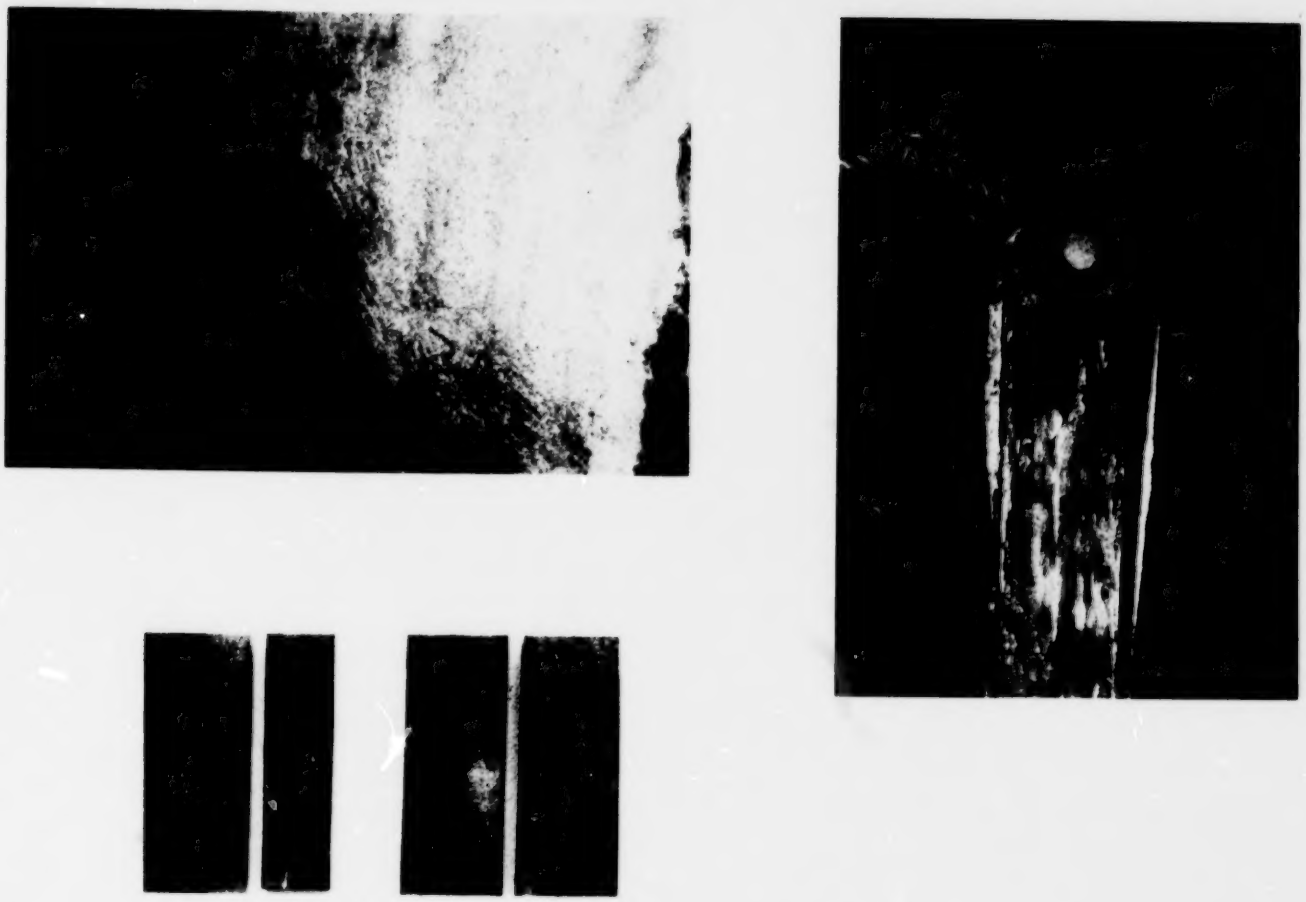


Figure 3

Detail of Field Joint (left), hanger (right)
and manhole cover sections (bottom)

Table 2

FRP Hanger Inspection - Hardness

	Header			
Location*	1	11	12	16
1	24	38	32	24
2	32	40	38	38
3	40	45	50	44
4	42	44	50	38
5	40	40	50	38
6	42	32	45	41
7	40	38	45	42
8	45	38	45	40
9	40	45	40	40
10	25	42	35	30
11	20	38	40	30
12	20	45		
13		40		
Thickness, cm	1.45	1.5	1.3	1.4

* As identified in sketch below.

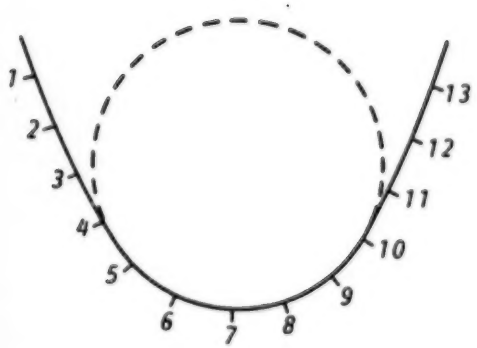


Table 3

FRP Flange Inspection - Hardness

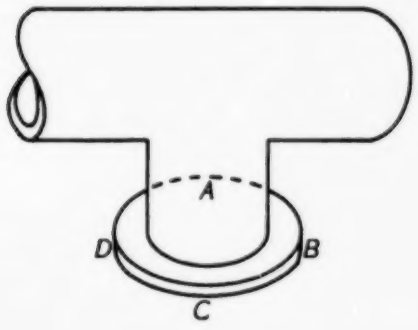
1. Hardness - Lower (Mating) Surface

Header	Location*			
	A	B	C	D
1	50	52	50	48
11	48	52	55	49
12	48	52	49	56
16	51	52	54	50

2. Hardness - Inner Surfaces

Header	A	B	C	D
1	38	40	42	40
11	25	38	40	40
12	30	38	38	40
16	30	30	30	34

* As identified in sketch below.



3. Material Samples and Repairs

As part of the header aging assessment, material samples were taken from each of the four headers and from one manhole cover for further laboratory evaluation. Repair procedures were prepared in collaboration with Protective Plastics and these are listed in Appendix 2. Repair procedures to the piping system were included with the inspection/repair program listed in Appendix 1.

Material samples were taken by Bruce Construction personnel under the supervision of Chemical Research staff. A detailed list of all sample locations is given in Appendix 3 and illustrated in Figure 2. Similarly all repairs were done by Construction personnel initially under the direct supervision of Chemical Research and later with a detailed inspection at each phase of the repair, particularly for the final inspection after cure. A detailed schedule of all repairs giving activity phase, date and inspector identity is given in Appendix 3.

All repairs were made according to the repair procedures with only minor variants: in the immediate vicinity of the spray plates the shape of the fiberglass patch was slightly modified so as to not cover the spray plates and retain the same total area of glass reinforcement. Repairs to the inner joints followed the same general procedure: grinding to sound glass, filling with thixotropic resin, covering with a set of glass, one set of veil and hot coat as given in Appendix 2.

4. Material Aging

At the request of the AECB for experimental in-situ evidence of the aging characteristics of the header material, a program was designed to obtain this information with minimum damage to the plant equipment. Two avenues were explored using either the manhole cover or a small header sample as source of material.

While the construction of the manhole cover differs somewhat from the pipe (a combination of molding and/or a hand lay up versus filament winding), the aging characteristics should be very similar. Furthermore the isotropic material lends itself better to mechanical testing of small coupons with virtually no impact on the existing system. It was found out however on testing one of the (10 year old) spare covers to gain baseline information that the manufacturing process had created small flaws /3/, as pictured in Figure 3. Larger flaws were also found on the newly made replacement covers (and labelled "New" in Figure 3). Not only were the samples unsuitable for the aging program but the decision was made to replace all existing covers, but using a different manufacturing process. To avoid the delamination problem the new covers were made entirely by hand lay-up to essentially the same specification for both resin and glass.

Four small samples were removed from Headers 11 and 12 and subjected to physical testing. The samples were in excellent condition as was the balance of the headers with no signs of significant deterioration. The samples were found to be made at a 55° wind angle with an average glass content of 64.3% for an average laminate density of $1.77 g/cm^3$. It was also confirmed by infrared analysis that the headers were made of identical inner and outer corrosion resistant resins and chemically different from the core material. Tensile properties (strength and modulus) were comparable to those of a recently made pipe of similar construction, indicating clearly the absence of any significant age related and/or environmental degradation/3/.

5. Conclusions

An inspection of vacuum building FRP components was carried out after 10 years of service. A complete visual inspection was performed on four of sixteen headers and associated components. Small material samples were cut from the headers for laboratory evaluation.

All FRP components were found to be in excellent condition with high hardness and no evidence of cracks or significant deterioration. Tensile properties compared favourably with a recently manufactured pipe of similar size and winding angle. Minor deficiencies included resin flaking on two headers and water ingress into three fields joints (out of all 32). Hard resin was found under the outer flaking and no repairs were deemed necessary. The affected field joints were repaired. All manhole covers were replaced during the outage.

It is recommended that improved methods to assess FRP degradation be developed before the next vacuum building inspection to limit the damage to header materials.

Acknowledgements. The assistance of Fiberglas Canada in this program is gratefully acknowledged. All mechanical tests on covers and coupons were performed at their Guelph R&D facility by Mr A.D. Osborne.

Approved by:

D.J. Dodd
Acting Manager
Chemical Research Department

Prepared by:

J.M. Braun
Project Leader -
Materials Research
Materials Chemistry Section

Reviewed by:

R.W. Glass
Supervising Chemist
Materials Chemistry Section

APPENDIX 1

INSPECTION PROGRAM - BRUCE NGS "A" VACUUM BUILDING

As part of the Bruce NGS "A" vacuum building inspection, the fiberglass spray headers should be inspected.

1. Inspection of Headers

Four of the sixteen headers and their associated hangers should be inspected including internal and external inspections. This can be performed only after all water has been drained from the headers.

The inspection is visual as per ASTM D2563, 3.1. Each part shall be checked visually without the aid of magnification. Standard procedures shall be followed such as described in ASME Code Case N-155-2 Fiberglas Thermosetting Resin Pipe and ASTM D2563 Classifying Visual Defects in Reinforced Laminate Parts. The inspection would detect defects, chemical degradation of fibres and resin or fractures. A copy of Tables 2900 - 2A, 2B and 3B of ASME Code Case N-155-2 is attached. This describes the types of defects.

In addition to the visual inspection, BARCOL hardness and thickness measurements should be made at random in each of the four headers. Measurements shall be at approximately every 30 cm along each header or closer if a joint is found. These measurements should be concurrent with the inspection of inner and outer surfaces of pipe. Thickness measurements are taken with a magnetic gauge (Polygauge). This instrument, which requires access to both faces is insensitive to the make-up of the non- metallic pipe wall. Photographic documentation should also be made where applicable.

One sample approximately 5 cm in diameter should be taken per header (at 12 o'clock) for glass content and winding angle. This is for documentation purposes. The samples should be identified with respect to the header and location.

The hangers will be inspected at the same time as the associated headers in a like fashion as will the associated metallic components and metal/FRP interface.

2. Failure Criteria

Minor cracks in the pipes over small lengths may be covered by either an polyester patch or additional hand lay-ups around the area of the crack. In the presence of large cracks over long lengths, frequent cracks (within each

pipe), cracks occurring in similar locations on all four tubes, then all tubes may have to be inspected and may result in more serious repairs.

Major cracks or deterioration of the resin of the hangers would necessitate the replacement of the hanger.

3. FRP Repair Procedures

All repairs shall be made by personnel experienced in the handling of the polyester resins and catalysts, used in the repair of FRP parts.

Personnel from the Chemical Research Department have experience with this type of repair and will be available for the inspection and necessary repairs.

All areas to be repaired must be absolutely dry. It may be necessary for the site to supply hot air heaters.

3.1 FRP Hand Lay-up for Minor Cracks

(a) Thoroughly dry the damaged area (with hot air blower if required).

(b) The surface area is to be sanded to yield a dust and moisture free area. All areas should be sanded at the same time. The sanding should extend six inches from both ends of the crack and three inches from the sides. Clean sanded area with alcohol or acetone.

(c) Coat the sanded area within 24 hours with a layer of catalysed resin by brush.

(d) Immediately imbed glass cloth or tape into the wet resin. Cover the entire coated area with the glass.

(e) Apply a generous coat of the resin. Make sure the glass cloth is completely saturated and all air bubbles have been brushed out.

(f) Repeat steps "d" and "e" and allow to cure for 24 hours.

(g) Do not use any mixed resin that has become too hot or started to gel.

(h) Inspect the repaired area after 24 hours. Sand any rough edges and apply a finishing coat of resin. Cure for 24 hours and inspect.

Note: Curing times can be speeded up with the addition of heat. Care should be taken not to overheat. This could cause scorching or cracking of the resin.

A Barcol hardness of 30-40 is indicative of adequate cure.

3.2 Repair Procedure For Sample Holes

Sample holes, where 5 cm discs were removed for analysis, must be repaired from the inside and outside of the spray headers.

Inside and Outside

(a) Insert a tight fitting plug of fiberglas, edges treated with resin, into the sample hole. Allow to cure for 12-24 hours.

(b) Sand both inside and outside (an area of approximately 6" x 6".

(c) Coat sanded surfaces with catalysed resin.

(d) Imbed glass cloth or tape into the wet resin.

(e) Apply a generous coat of resin. Make sure the glass is completely saturated. Brush out all air bubbles.

(f) Repeat steps "d" and "e" and allow to cure for 24 hours.

(g) Inspect the repaired area after 24 hours. Sand any rough edges and apply a finishing coat of resin. Cure for 24 hours and inspect.

4. Requirements

4.1 Hardware

All inspection equipment and FRP patching compounds will be provided by the Research Division.

Hot air heaters will have to be supplied by site personnel.

4.2 Labour

Three eight hour shifts by four research staff experienced in FRP people are required to complete the inspection, take the FRP samples and repair the corresponding holes.

Additional repairs may be required as a result of the inspection. Note however that no FRP repairs were needed at Pickering NGS.

APPENDIX 2

BRUCE NGS A VB SPRAY HEADERS

Repair procedure as recommended by Protective Plastics

The following is the repair procedure recommended by Protective Plastics when samples are taken out of the spray headers. It was indicated to them that two types of samples are proposed to be taken out of the spray headers: 5 cm diameter samples and 15 cm by 2 cm samples.

1. For the 5 cm holes, the following steps are recommended by Protective Plastics.

1.1 Outside surface:

Step 1: An area of at least 30 cm ($\simeq$ 700 cm^2) diameter of the surface of the spray header must be ground down to expose the glass.

Step 2: Make up sets consisting of one layer of mat, one layer of woven roving and one layer of mat. This would make up a thickness of approximately 0.3 cm. The diameters of the covering set are as required in steps 3 and 5 below.

Step 3: In addition to the plug, the first set of covering should be at least 10 cm diameter. The next covering set should be between 13 and 15 cm in diameter. The third covering set should be between 15 and 18 cm in diameter.

Step 4: After the third covering set, a curing time of at least 2 to 3 hours must be allowed.

Step 5: The fourth* covering set, when applied, should be between 18 and 20 cm in diameter. The fifth* covering set should be between 20 and 23 cm in diameter. The last* covering set should be between 23 and 25 cm in diameter.

Step 6: Allow to cure for at least 2 to 3 hours.

Step 7: After this, the area which was ground previously must be covered with resin.

Step 8: Allow for cure for at least 18 hours.

* These have been increased 1.3 cm to compensate for the material lost in cutting the notch at the spray plates.

1.2 Inside Surface

Step 1: An area of at least 15 cm diameter must be ground to expose the glass.

Step 2: After the plug is in place, 2 layers of mat and one layer of veil (as the inner most layer) should be added as reinforcement.

Step 3: Allow for cure for at least 2 to 3 hours.

Step 4: For the area that was ground previously (namely 15 cm diameter), hot coat with resin.

Step 5: Allow to cure for at least 12/18 hours with a Barcol hardness of at least 25.

2. For the rectangular samples of 15 cm by 2 cm, the following procedure is recommended by Protective Plastics:

2.1 Outside Surface:

Step 1: An area of at least 45 cm by 30 cm must be ground to expose the glass.

Step 2: Make up covering sets consisting of one layer of mat, one layer of woven roving and another layer of mat. This would make up a thickness of approximately 0.3 cm. The size of the covering set must be as per steps 3 and 5 below.

Step 3: In addition to the plug that will be placed in the rectangular hole, the first covering set should be 20 cm by 7.6 cm; the second covering set should be between 23 cm and 25 cm by 10 to 13 cm and the third covering set should be between 25 cm and 28 cm by 13 to 15 cm.

Step 4: Allow at least 2 to 3 hours for these three covering sets to cure.

Step 5: Add on the next three covering sets as per the following: The fourth covering set should be between 28 cm and 30 cm by 15 to 18 cm. The fifth covering set should be between 30 cm and 33 cm by 18 to 20 cm and the sixth covering set should be between 33 cm and 36 cm by 20 to 23 cm.

Step 6: Allow to cure for at least 2 to 3 hours.

Step 7: The area that was ground prior to additional covering set lay up (namely 46 cm to 30 cm) must be completely covered with resin.

Step 8: Allow at least 12 hours to cure (Barcol hardness after 12 hr of at least 25).

2.2 Inside Surface:

Step 1: An area of at least 25 cm by 13 cm to be ground to expose the glass.

Step 2: After the plug is in place, two layers of mat and an inner most layer of veil should be added as reinforcement.

Step 3: Allow to cure for at least 2 to 3 hours.

Step 4: Over the area that was ground (namely 25 cm by 13 cm), hot coat with resin to cover the ground out surface completely.

Step 5: Allow to cure for at least 12 hours (Barcol hardness after 12 hr of at least 25).

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APPENDIX 3

SCHEDULE OF FRP HEADER REPAIRS

Repair Location Header	Repair Type	Sample Removal	Plug/ Thixotropic Resin Installed	Surface Grinding	Outer Surface 1st 3 Sets of Glass	Outer Surface 2nd 3 Sets of Glass	Inner Surface Set of Glass	Hot Coat Of Resin Outer	Hot Coat Of Resin Inner	Final Inspection Outside Barcol	Final Inspection Outside Date	Final Inspection Inside Barcol	Final Inspection Inside Date
#1	disk	May 9/RW	May 10/RW	May 13/RW	May 13/RW	May 13/RW	May 15/RW	May 16/BW	May 16/BW	31	May 17/RW	28	May 17/RW
#16	disk	May 9/RW	May 10/RW	May 13/BW	May 13/RW	May 13/RW	May 15/RW	May 16/BW	May 16/BW	32	May 17/RW	25	May 17/RW
#11	disk	May 9/RW	May 12/RW	May 13/BW	May 13/RW	May 14/RW	May 16/BW	May 16/BW	May 16/BW	26	May 17/RW	25	May 17/RW
#12	disk	May 9/RW	May 12/RW	May 13/BW	May 13/RW	May 14/RW	May 16/BW	May 16/BW	May 16/BW	31	May 17/RW	29	May 17/RW
#11 A*	rect.	May 9/RW	May 10/RW	May 13/BW	May 14/BW	May 16/BW	May 16/BW	May 16/BW	May 16/RW	32	May 17/RW	28	May 17/RW
#11 B	rect.	May 9/RW	May 10/RW	May 13/BW	May 14/BW	May 16/BW	May 16/BW	May 16/BW	May 16/RW	31	May 17/RW	30	May 17/RW
#11 C	rect.	May 9/RW	May 12/RW	May 14/BW	May 15/RW	May 16/BW	May 16/BW	May 16/RW	May 16/RW	32	May 17/RW	29	May 17/RW
#11 D	rect.	May 9/RW	May 12/RW	May 14/BW	May 15/RW	May 16/BW	May 16/BW	May 16/RW	May 16/RW	35	May 17/RW	30	May 17/RW
#12 A	rect.	May 9/RW	May 10/RW	May 13/BW	May 16/RW	May 17/RW	May 16/BW	May 17/RW	May 16/RW	25	May 17/RW	28	May 17/RW
#12 B	rect.	May 9/RW	May 10/RW	May 13/BW	May 16/RW	May 17/RW	May 16/BW	May 17/RW	May 16/RW	28	May 17/RW	25	May 17/RW
#12 C	rect.	May 9/RW	May 12/RW	May 14/BW	May 16/RW	May 16/BW	May 16/BW	May 16/BW	May 16/RW	30	May 17/RW	31	May 17/RW
#12 D	rect.	May 9/RW	May 12/RW	May 14/BW	May 16/RW	May 16/BW	May 16/BW	May 16/BW	May 16/RW	28	May 17/RW	33	May 17/RW
#11	joint	-	May 15/BW	May 15/RW	-	-	May 16/RW	-	May 16/RW	-		25	May 17/RW
#12	joint	-	May 16/BW	May 15/RW	-	-	May 16/RW	-	May 16/BW	-		42	May 17/RW
#9	joint	-	May 16/BW	May 16/BW	-	-	May 17/BW	-	May 17/BW	-		28	May 17/BW
#5	blemish	-	-	May 16/BW	May 16/BW	-	-	May 16/BW	-	32	May 17/RW	-	-

* A,B samples taken near catwalk
C,D samples taken mid-span, near field joint

RW - Rick Winn
BW - Burt Worth

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3. Osborne, A.D., Letter to: Mr. M. Beattie, Design Engineer Specialist, Fiberglas Canada, File ADO 47-87, May 14, 1987.

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